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USMC KC-130J CREW COMPOSITION

by

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Abstract

With the advent of the "glass cockpit" in the KC-130J, the Marine Corps faces tough decisions about reducing the crew complement. Designed for three crewmembers, the KC-130J potentially reduces the crew complement in half. This paper looks at the negative impacts that drastic crew reductions would have on the safety and efficiency of the KC-130 community.

The analysis begins with a look at the extraordinary safety record of the KC-130 community and the training regimen. Next, the analysis looks at the capabilities, limitations, and the Cockpit Resource Management issues of glass technology. Finally, an analysis of a closely related aircraft, the C-17, is conducted to assess KC-130J training resource deficiencies.

The analysis shows lack of training resources significantly degrades the safe operations of the KC-130J. The arrival of this new aircraft will not bring any substantial increase in training sortie opportunities. With a drastic reduction in crew complement, the KC-130 community will be severely strained to keep aircrews proficient.

With relatively young aircrew and minimal training opportunities, the risk to safety of flight increases substantially without the contributions of the crew positions eliminated from the KC-130J. The Marine Corps would be well served to take a long-term transition strategy of maintaining the relative same crew complement until such time that appropriate training resources are available and the crew can be gradually reduced.

Chapter 1

Introduction

> ***MARINE AERIAL REFUELING SQUADRON – KC-130 MISSION***. *Provide Aerial Refueling service in support of air operations; provide Assault Air Transport for personnel, equipment, and supplies, and to conduct such other air operations as may be directed.*
>
> —MCO P3500.14F

The United States Marine Corps KC-130 has been an integral part of the Marine Air Ground Task Force since the aircraft's introduction in 1960. Over the last 40 years, Marine KC-130 aircrews have evolved into a highly effective and safe team capable of reliably accomplishing the mission while maintaining an incredible safety record. The challenge that the community now faces is the introduction of the new KC-130 J model aircraft. With the advent of the "glass cockpit" in the KC-130J, the manufacturer, Lockheed Martin, has developed the aircraft around a crew complement that reduces the crew by fifty percent. The focus of this paper is to discuss how drastic cuts in crew complement can have a negative impact on the overall efficiency and safety of the KC-130 community.

Glass technology has become more prevalent in aircraft throughout the 1990's. Fighter aircraft have become glass dependent. Commercial airlines have been able to reduce their flight deck crew composition from three to two people as a result of this technology. The United States Air Force C-17 was developed as a tactical transport aircraft with glass technology and a crew of three. Although glass technology is a desired technological advance, the KC-130 community must make a smart transition to this new capability.

This analysis begins with a background look at the current crew composition of the Marine KC-130 and its safety record as well as the KC-130J crew concept as developed by Lockheed Martin. How the crew operates has not only been key to the extraordinary safety record but also mission accomplishment. Advances in technology throughout the 40 years the Marines have been flying the KC-130 have no doubt helped with the mission success rate as well as safety record; however, glass technology is a radical shift in technology that requires substantial changes in training requirements and resources.

The next part of this analysis looks at the tremendous opportunities that glass technology provides as well as the challenges that the KC-130 community will face. Along with the advances in this technology, the Cockpit Resource Management (CRM) issues associated with glass technology are substantially different than with older analog instruments. Additionally, the interaction between the captain and the first officer in the airline industry provides good insight into some challenges faced by military transport aircrews. In order to effectively train for glass technology, the airline industry and the C-17 program have training resources that far exceed the resources that the Marine Corps projects to have available for its aircrews.

The final part of this analysis looks at the training resources cockpit and provides a KC-130J crew complement recommendation. A look at the C-17 aircraft provides the closest example to the KC-130J. The Air Force's successful implementation of its C-17 squadrons demonstrates that appropriate resources exist, both manpower and equipment, to employ a glass cockpit military transport aircraft with a three person crew. The Marine Corps can look at the resources and training program of the C-17 community to establish the minimum resources required before considering drastic cuts in crew complement.

Chapter 2

Background and Significance

The Marine Corps has been flying the KC-130 since 1960. Since the introduction of the aircraft, the Marine Corps has enjoyed an incredible safety record: the KC-130 community must be doing something right.[1] Between the Marine Corps and Air Force C-130 community, the Marines have a significantly better safety record. Although extensive research could be conducted to find out why, logically, one may conclude that Marine aircrew training and crew coordination techniques are a critical factor in the Marine Corps extraordinary KC-130 safety record. With this assumption, is it smart to arbitrarily accept the three person concept in the new KC-130J aircraft?

The basic crew composition of the current KC-130 aircraft consists of a pilot in command, copilot, navigator, flight engineer, loadmaster, and flight mechanic. Together, they form a crew that when properly trained can perform virtually all missions required in support of the Marine Air-Ground Task Force (MAGTF). The current KC-130 aircrew duties are spelled out in the NATOPS flight manual as follows: [2]

1. The pilot in command is responsible for the safe and orderly conduct of the flight.
2. The copilot is second in command and is responsible for assisting the PIC in the performance of his duties and such other duties as may be assigned. The copilot may control the aircraft and he shall constantly monitor all maneuvers being performed by the pilot, bringing to his attention any deviation from the normal operation.

3. The navigator plans the navigation phase of the mission. He navigates the aircraft to accomplish the mission. Additionally he identifies drop zones on missions involving aerial delivery of troops or equipment and rendezvous aircraft for air refueling. He is also responsible for the monitoring and operation of the DECM systems.
4. The flight engineer is responsible for the preflight and postflight inspections, and the takeoff, climb, cruise and landing performance data. In-flight he occupies the center seat on the flight station, monitoring the engine instruments and operation the electrical, fuel , pressurization, air conditioning, external lighting, auxiliary power and anti icing systems. He troubleshoots malfunctioning aircraft systems and initiates emergency procedures/actions as required by the NATOPS and/or the pilot in command. Additionally he may supervise the removal and replacement of all aircraft system components if qualified maintenance personnel are not available.
5. The loadmaster is qualified in loading and unloading the aircraft with either cargo or passengers. He computes the weight and balance. As the radio operator, he will operate the high frequency radios. During in-flight refueling, he will act as the in-flight refueling observer.
6. The flight mechanic occupies a position in the aft section of the aircraft. He assists the flight engineer with daily turnaround inspections, servicing, engine maintenance and securing of the aircraft. Additionally, when qualified, he acts as an in-flight refueling observer.

These crew positions have developed a crew coordination relationship that relies heavily on crewmembers speaking up and supporting one another during normal operations as well as in times of emergency. The result is an incredible safety record.

The Marine KC-130 safety record stands out in comparison to the Air Force C-130 safety record. The last flight related class “A” mishap for the Marine KC-130 community was prior to 1980. Since then, the Marine KC-130 community has accumulated over 650,000 hours of mishap free flight time, which makes the mishap rate 0.[3] The mishap rate is important because it takes into account the number of aircraft hours flown. By comparison, the USAF C-130 mishap rate is 0.42 per 100,000 flight hours over the same time frame resulting in 238 fatalities.[4] The Air Force averaged 1.4 class “A” mishaps per year. Once again, from a broad perspective, the Marine KC-130 community must be doing something right. Crucial to the safety record is the synergy of aircrew interaction and combined experience from all crewmembers. However, there is a strong possibility a reduction in crew will reduce the margin of safety inherent in the traditional crew complement.

Lockheed Martin knew there was a need to replace the aging C-130 fleet so they developed the C-130J with a three-person crew and obtained FAA certification.[5] It is important to note that the aircraft was *not* designed through the normal acquisition process of establishing requirements and then having the contractor develop the aircraft. The C-130J is a commercial off the shelf product resulting in the Marine Corps making this aircraft comply to its requirements instead of identifying the requirements up front and developing the aircraft to fit. Although this aircraft looks like a C-130, with the advent of glass technology, the flight deck is radically different forcing significant changes to crew operations.

The C-130J was developed with a crew composition consisting of a pilot in command, a copilot and a loadmaster.[6] At the cost of increased workload for the pilots, technology can allow them to assume the navigation duties of the navigator and the systems monitoring duties of the flight engineer. Additionally, the preflight/postflight duties of the Navigator, Flight Engineer, and the Flight Mechanic will have to be assumed by the pilot, co-pilot and the loadmaster resulting in longer preflights and longer turnaround times. The increase in workloads may be acceptable as long as the flight is a fairly benign mission and the crew does not encounter any problems.

Although it has been demonstrated through the FAA certification process that the aircraft can be flown with a crew of three, it does not take into account the mission requirements for the end users. Flying the C-130J from point A to point B is no different than a basic airliner. The cockpit is adequately designed to handle that type of mission as evidenced by the FAA certification. Additionally, the airlines have a substantial support infrastructure wherever they land. The problem that faces the KC-130 community is the unique mission requirements and the requirement for a single aircraft to operate independently throughout the world without a support infrastructure.

The KC-130 community conducts unique missions that have a substantially higher task loading than flying from point A to point B. Removing the flight engineer and navigator will substantially reduce the combined aircrew experience level, a crucial part of the support system for the aircraft commander. Additionally, with the loss of the flight engineer's maintenance experience, the Marine Corps will reduce its capability of being able to operate independently around the world. If this capability is not maintained on the aircraft, squadrons will potentially have to increase the size of their maintenance decks causing maintenance personnel to deploy with the aircraft: no real savings in manpower.

When you assess the experience levels, current capabilities and training resources of the Marine aircrew, significant challenges exist in bringing the KC-130J aircrew capability up to a level commensurate with the current safe and effective capability of the current KC-130 community.

Notes

[1] USMC Safety Statistics, U.S. Marine Corps Safety Division, Online, Internet, Available from http://www.hqmc.usmc.mil/safety.nsf/$about?OpenAbout.

[2] Natops Flight Manual, Navy Model, KC-130F/C-130F Aircraft, 1 April 1993, 15-1.

Notes

[3] USMC Safety Statistics, U.S. Marine Corps Safety Division, Online, Internet, Available from http://www.hqmc.usmc.mil/safety.nsf/$about?OpenAbout.

[4] USAF Safety Statistics, Air Force Safety Center, Online, Internet, Available from http://www-afsc.saia.af.mil/AFSC/RDBMS/Flight/stats/c130mds.html.

[5] Department of Transportation, Federal Aviation Administration Type Certificate Number A1SO, 9 September 1998.

[6] C-130J Receives FAA Certification, Lockheed Martin Press Release, 9 September 1998, Online, Internet, Available from http://news.lmasc.com/article.htm?article_id=75.

Chapter 3

Current Capabilities and Training Resources

The mission of the Marine Aerial Refueling Squadron is to provide Aerial Refueling service in support of air operations; provide Assault Air Transport for personnel, equipment, and supplies, and to conduct such other air operations as may be directed.[1] In order to facilitate the mission, the following Mission Essential Task List(METL) was established delineating the capabilities that the KC-130 community must be capable of.

MISSION ESSENTIAL TASK LIST

1. Provide tactical and long range aerial refueling.
2. Provide rapid ground refueling service to aircraft and vehicles.
3. Provide assault air transport for air landed troops, supplies and equipment.
4. Provide air delivered troops, supplies and equipment.
5. Provide airborne platform for the airborne DASC command post.
6. Within the capability of the aircraft, operate under day/night, all weather conditions, with or without airborne, surface or ground controllers.[2]

With the multiple missions assigned, it can be quite challenging to train the aircrew and maintain aircrew proficiency in the core skills required in support of the METL. With high external support missions, squadrons have very few aircraft left over to conduct their own training. As such, getting as much training possible out of the external support missions assigned is a constant challenge for the aircrew-training officer. In order to ensure currency for the aircrews in the various mission, the aircrew-training officer utilizes the refly factors in the Training and Readiness Manual (T&R).[3]

The refly factors for the core skills required in support of the METL are quite lengthy. For most of the daytime skills like Aerial Refueling, Low Level Navigation, Formation, Aerial Delivery and Rapid Ground Refueling the T&R manual only requires the pilots to fly that mission once in the last 12 months to be current.[4] Because of the primary Aerial Refueling (AR) mission, most of the pilots fly AR missions far more frequently than once per year. However, skills like Formation, Low Level Navigation and especially Aerial Delivery (AD) are much harder to maintain currency because training sorties are limited with high external support mission requirements.

With lengthy refly factors establishing the minimum requirements to maintain proficiency, the impact the rest of the crew has on the pilots must be considered. Both the Navigator and the Flight Engineer make significant contributions to reduce the workload on the pilots and assisting in the safety and success of the mission. Aside from their primary duties during the missions, they also provide assistance with monitoring the radios, looking for traffic, acquiring aircraft during the AR rendezvous portion, acquiring the drop zone as well as backing up the pilots on instrument approaches in bad weather and acquiring the runway. During emergencies, the flight engineer's input is crucial in assisting the aircraft commander in making informed decisions. The navigator's quick assessment and recommendations provide the aircraft commander with valuable options. The knowledge and experience that the navigator and flight engineer contribute to the crew make it possible to have lengthy refly factors and still maintain safe and proficient pilots while providing valuable assistance to relatively inexperienced pilots.

Another aspect to consider is the experience level of our pilots. The major airlines require the most junior pilot (first officer) to have at least 1500 hours flight time which is the minimum requirement for an Airline Transport Pilot (ATP) rating. Airline captains obviously have substantially more flight experience than first officers do. The KC-130 NATOPS flight manual requires a copilot to have at least 1500 hours before upgrading to Pilot in Command. The KC-130 community is waiving that requirement to as low as 850 - 950 hours. Although it sounds like a dramatic cut in experience it is not necessarily a bad policy. With the KC-130 operations going from more of long-range Aerial Refueling missions to more frequent short-range tactical missions, the pilots are able to complete the T&R syllabus requirements for upgrade. Although technically ready for the job, the new young Aircraft Commander has missed out on hundreds of hours of experience copilots used to get prior to upgrading. Squadron commanders take comfort in the fact that there are highly qualified flight engineers and navigators on the flight deck supporting the aircraft commander.

The flight engineer and the navigator have been ingrained in the KC-130 crew concept. Not only are they effective in assigned duties, but they have also played a key role in the avoidance of accidents. Replacing these two positions on the flight deck with glass technology will require a radical shift in mindset, crew coordination, training, and possibly experience levels.

Notes

[1] Marine Corps Order P3500.14F, *T&R Manual Volume 1*, *Administrative*, 14 February 1999, A-9.

[2] Ibid., A-9.

[3] Ibid., 9-4.

[4] Marine Corps Order P3500.15C, *Ch 1 T&R Manual Volume 2, Tactical Fixed-Wing*, 13 January 2000, 6-65.

Chapter 4

Glass Technology

> *My F/O, new on the aircraft, took over on the CDU and in trying to oversee her attempts to get the waypoint inserted I did not get the aircraft on the proper descent profile, resulting in crossing 10 East of PMD 1500-2000 feet high. The primary factor I feel was not flying the aircraft instead (I was) attempting to program and/or supervise the F/O. A contributing factor was the constant distraction of the caution light.*
>
> ASRS No. 139213

Glass cockpits are advanced cockpits consisting of electronic displays rather than conventional "steam gauge" instruments providing a dramatic shift in technology.[1] Pilots are always looking for advanced technology in their cockpits. The automation provided by this technology increases the pilot's situational awareness, automates many of the tasks from the older technology, and provides a means to reduce the crew size on the flight deck. The airline industry is the largest user of glass technology and controversy exists over reduction in crew size, especially on over-water flights.[2] However, most pilots that have flown the high-technology aircraft are satisfied with the two-pilot crew station.[3]

Glass technology significantly enhances the pilot's situational awareness as well as making more aircraft information available to the pilot. Traditional instrumentation gave way to computer-generated color graphics and text, and stored navigational information took much of the drudgery out of the pilot's task.[4] This allows the pilot to have more information about the aircraft available in a suitable location to the pilot, virtually at their fingertips. With stored navigational data, flight plan input into computers is much easier. One of the more popular features in glass cockpits is the ability to merge navigation data and weather radar data into one display allowing the pilot to quickly determine alternate courses of action in and around bad weather.[5] With aircraft instrumentation readily available to the pilot through glass and the flexibility that it affords, pilots are able to increase their level of situational awareness thus increasing safety. Additionally, many of the functions performed by the flight engineer like systems monitoring are being turned over to computers thus allowing a reduction in crew size.[6]

The three-person crew is a disappearing phenomenon in commercial aviation with the three-pilot aircraft being retired from airline fleets as modern, two-pilot models arrive[7]. Automation allowed the number of crewmembers reduced to two as both aircraft systems and flight management (navigation) systems become automated. Duties previously assigned to the flight engineer are now largely the direct responsibility of the first officer.[8] This is an obvious economical advantage for the airline industry and can provide the same economical advantage for military transport aircraft. Although automation tends to lower the physical workload on the flight crew, the flight management system (FMS) is an another highly complex system that needs to be well understood by the crew.[9]

Automation does not reduce training requirements. Automation in the glass cockpit and the Flight Management System (FMS) are two aspects that must be well understood by the pilots. With the reduction in crew size, more reliance must be placed upon automation to show the pilot what he or she needs to know. Even if automation were fully capable of always showing pilots what they need to know, the aircrew needs to fully understand all systems of the aircraft. In addition to understanding all "traditional" systems on the aircraft (fuel, electrical, hydraulic, etc.), the crew must also understand the FMS, creating additional training requirements.[10 11]

The FMS is a major workload reliever for the crew when it has been properly programmed prior to flight. However, it can actually substantially increase the workload on the crew if information needs to be inserted during a flight due to changes in the flight plan or the FMS is responding to a non-routine event.[12] Rerouting often occurs in flight requiring the reprogramming of the FMS. This increases the heads down time for one, if not both of the pilots, while the flight plan is being programmed into the computer. Additionally, during non-routine events, not only does the pilot have to deal with the uncertainty of the events; the pilot now has to contend with uncertainty about the FMS and how it is going to respond. How the pilots interact in their Crew Resource Management (CRM) during these non-routine events will effect the overall safety of the flight.

CRM is crucial to the safe and effective operation of the glass cockpit. Weiner undertook an extensive study of human factors in the glass cockpit focusing on crew coordination and communications. Here are some of the CRM oriented observations he developed that compared traditional aircraft to glass cockpit aircraft:

1. Compared to traditional models, it is physically difficult for one pilot to see what the other is doing. In traditional models, the setting of the autopilot and other modes could be observed easily by both pilots. In the glass cockpit models, the important selections are made in the CDU and this is not visible to the other crew member unless he or she selects the identical CDU page or leans across the pedestal to observe the first officer's CDU, as many captains do.
2. It is more difficult for the captain to monitor the work of the first officer and to understand what he is doing, and vice-versa.

3. Automation tends to induce a breakdown of the traditional roles and duties of the pilot flying versus pilot-not-flying and a less clear demarcation of “who does what” than in traditional cockpits. In aircraft in the past, the standardization of allocation of duties and functions has been one of the foundations of cockpit safety.
4. There is a tendency for the crew to “help” each other with programming duties when workload increases. [13]

Since these observations apply to experienced aircrews, they could have a substantial safety impact on junior military crews. This impact is even more important when you consider what an experienced 767 captain emphasizes about the importance of crew communication in the high technology aircraft:

> Standardization of cockpit operations is critical in the new technology aircraft. More than ever, pilots can change configuration or operation parameters without the other pilot being aware of the change. This is not done out of maliciousness but rather as a consequence of systems needs. ATC communications, aircraft reconfiguration, or other demands put pilots in a position where each must act independently at times. It is imperative in these occasions for each to understand what the other pilot has done. This type of cockpit communications is the essence of cockpit resource management courses prevalent in many air carrier-training curricula. [14]

Glass technology provides the sensible next step in cockpit automation however it can be a challenging step for the KC-130 community. The airline industry is utilizing this technology with much success and satisfaction. A key point to consider is the experience level of the pilots utilizing this technology in a crew oriented transport aircraft. As mentioned earlier, the minimum flight time most airlines will accept is 1500 hours. The most junior pilot (first officer) in the airline flight deck has at least that amount of flight time. KC-130 pilots average substantially less than that. Currently, the average flight time of a junior officer who is an Aircraft Commander is around 1350 hours. Some have less than 1000 hours in the KC-130. An important consideration is the aircraft commander supervising a copilot whose average flight time is around 600 hours.

Glass technology is a radical jump in technology for a group of relatively inexperienced pilots flying transport aircraft. The aircrews working with the pilots, and a highly effective CRM program, have allowed the KC-130 community to maintain an outstanding safety record with 30-40 year old aircraft. Reducing half of the crew and increasing the training requirements places an increased strain on training resources, an increased burden on the young aircraft commanders, substantially changes how CRM is utilized on the flight deck, and substantially reduces the margin of safety established in the Marine KC-130 community.

Notes

[1] O'Neil Jr., H.R. and Andrews, DH. *Aircrew Training and Assessment*. Mahwah, New Jersey: Lawrence Erlbaum Associates, Inc., 2000, 18.

[2] Wiener, E.L., Kanki, B.G., and Helmreich, RL., *Cockpit Resource Management.* San Diego, Ca: Academic Press, Inc., 1993, 205.

[3] Ibid., 205.

[4] Ibid., 206.

[5] Ibid., 206.

[6] Ibid., 207.

[7] Ibid., 207.

[8] O'Neil Jr., H.R. and Andrews, DH. *Aircrew Training and Assessment*. Mahwah, New Jersey: Lawrence Erlbaum Associates, Inc., 2000,18.

[9] Ibid., 26.

[10] Ibid., 26.

[11] Wiener, E.L., Kanki, B.G., and Helmreich, RL., *Cockpit Resource Management.* San Diego, Ca: Academic Press, Inc., 1993, 472.

[12] O'Neil Jr., H.R. and Andrews, DH. *Aircrew Training and Assessment*. Mahwah, New Jersey: Lawrence Erlbaum Associates, Inc., 2000,175.

[13] Wiener, E.L., Kanki, B.G., and Helmreich, RL., *Cockpit Resource Management.* San Diego, Ca: Academic Press, Inc., 1993, 210.

[14] Ibid., 211.

Chapter 5

Cockpit Resource Management

It is the team, not the aircraft or the individual pilots, that is at the root of most accidents and incidents.

—Robert L. Helmreich

Efficient Cockpit Resource Management (CRM) is at the root of all safe transport aircraft operations. In the great majority of aircraft accidents, the aircraft was mechanically capable of flying out of the situation, all crew members were well trained and in good health, and yet the crew got itself into trouble.[1] How the captain interacts with the crew sets the tone for how effective CRM will be in that cockpit. Experience also plays an important part in the decision making process and CRM. Additionally, the military cockpit environment has additional workload issues that impact CRM and safe mission accomplishment.

The authority relationship between the captain and the rest of the crew has both positive and negative effects and must be carefully considered in crew dynamics. The combination of aviation history, regulations, and crewmember characteristics has established an authority dynamic that undoubtedly has a positive impact on the aviation safety record.[2] This reliance on the captain works well in time critical situations. However, the tendency toward the high-authority end of the continuum has resulted in crewmembers not speaking up when necessary. This inclination may also result in excessive psychological dependence on the captain as leader to the extent that individual contributions to problem solving are neither voiced nor attempted.[3] For example, Robert C. Ginnett said "one captain with whom I flew made a particularly poor approach which resulted in an excessive dive on short final, thus setting off numerous alarms. In reviewing the crewmembers' inaction afterward, the young second officer (who literally said nothing during the final approach) admitted that he had never seen an approach quite like that, but figured "the captain must know what he's doing."[4] Considering the experience that these professional airline pilots have, this situation can be magnified when looking at a young military crew where new copilots have but a few hundred hours of flight time. This sets up a steep intra-cockpit authority gradient between the aircraft commander and the copilots in many military cockpits.

The intra-cockpit authority gradient is a management relationship that exists between the aircraft commander and the crew. With a strong authoritarian aircraft commander and a weak copilot there is a steep intra-cockpit authority gradient.[5] This situation is considered dangerous and the reason for several CRM failures that have resulted in airline industry accidents. A moderately strong captain and a strong co-pilot result in a shallow authority gradient. This situation is considered ideal for safety and crew effectiveness. [6] Although most new copilots are strong, by virtue of being brand new in the cockpit, there will be a tendency to defer to the aircraft commander. A factor that exacerbates the steep authority gradient is a situation where the aircraft commander is less than technically competent.

A less than technically competent aircraft commander could adversely affect safety of flight if a young inexperienced copilot is apprehensive about challenging the aircraft commander. A less technically competent crewmember may be highly defensive in order to preserve a competent self-image possibly resulting in the crewmember maintaining unrealistic and self-deceptive attitudes of personal competence, resistance to stress and lack of need for support from other crewmembers. This person may project an air of all-knowing confidence and independence when, in fact, the opposite is true.[7] Although it would be nice to assume that all aircraft commanders and copilots are trained to be technically competent and to be prepared to challenge other crewmembers, it is unrealistic to think that the training will be universally successful.

As discussed in the last chapter, the advanced technology of glass cockpits will require additional training. Additionally, with the reduction of crewmembers, an additionally larger training burden will be placed upon the remaining crew. With the reduction in crewmembers comes the loss of collective experience on the aircraft. This creates a situation where substantial increases in training can make up for part of the reduction in crew, however, there is no way to make up for the loss of experience of the other crew members. This loss of experience directly impacts how pilots make decisions.

Experience plays a large role in how pilots make decisions. It is reasonable to assume that when confronted with a problem a pilot will evaluate and compare the options and then select the most prudent path. However, many situations in aviation do not allow time to conduct such an analysis. Under time pressure, pilots often look for the first workable option and don't care about finding the absolute best.[8] So if pilots aren't comparing options, how are they making decisions? It has been determined that skilled decision-makers can use their experience to generate an effective option as the first one they consider. Below are some of the assertions that Klein, Calderwood, & Clinton-Cirocco utilize in their model to explain how pilot can accomplish this.

1. People are able to use their experience to size up a situation as familiar.
2. By recognizing a situation, people can generate a reasonable option as typical
3. Usually, this typical option is the first on they consider. [9]

Klein also states that the most common reason for poor decisions is a lack of experience.

1. It takes a high degree of experience to recognize situations as typical; to notice anomalies, it is first necessary to recognize typicality so that you can see when something unusual has happened.
2. It takes a high degree of experience to build stories to diagnose problems and to mentally simulate a course of action.
3. It takes a high degree of experience to prioritize cues, so workload won't get too high.
4. It takes a high degree of experience to develop expectancies and to identify plausible goals in a situation. [10]

The point to consider here is what do crewmembers that are not so experienced rely on? With a large crew there is usually assistance readily available. However, reduce that crew and replace them with automation, will the remaining crew have the experience to generate effective options in time critical situations? What about the additional burdens that are placed upon relatively inexperienced military pilots over professional airline pilots?

Commercial airlines have as their charter the safe transport of people and freight from one location to another with safety of flight as the primary consideration.[11] Airlines fly routine routes between fairly developed airports. While military KC-130 aircrews are expected to keep safety of flight as a primary consideration, they must also complete training to support their mission. The military training requirements far exceed the standard passenger point to point profiles that the airlines conduct. As such, the KC-130 aircrew must share their attention between requirements of their mission and safe conduct of flight.[12] While the highly experienced airline pilots are required to safely transport passengers in a fairly benign environment, the young KC-130 pilots must accomplish this task as well as the training requirements in a dynamic, ever changing environment which can cause different types of decisions to be made.

KC-130 aircrews are always trying to accomplish the training in support of the overall mission. When problems arise, there is not always a clear-cut solution. Military crews are in constant preparation for combat, and this is likely to cause them to select a riskier alternative than a crew of an airline. A more conservative decision may be made during a training mission and a more dangerous alternative may prevail during war, when completion of a mission may be extremely important.[13] The additional crewmembers enhance the safety of flight by providing the experience to assist the aircraft commander in making those decisions.

The assumption that reducing the crew size in the airline industry works as a result of glass technology is not a fair comparison to the glass cockpit in the KC-130. Many of the flights required in military aviation include a greater proportion of unknowns than do routine flights in civil aviation.[14] The METL the KC-130 community must train for results in far more complicated mission profiles than the airline industry. Additionally, airline pilots have far more experience than do the young KC-130 pilots making it easier to adapt to glass technology with reduced crew. The combination of complex missions, less experienced crew and reduced crew complement is a recipe for mishaps. In order to begin to employ the KC-130J safely and effectively, a mindset is required other than arbitrarily reducing the crew to three or four persons.

Notes

[1] Wiener, E.L., Kanki, B.G., and Helmreich, RL., *Cockpit Resource Management.* San Diego, Ca: Academic Press, Inc., 1993, 48.
[2] Ibid., 88.
[3] Ibid., 88.
[4] Ibid., 88.
[5] Jensen, RS., *Pilot Judgement and Crew Resource Management.* Brookfield, Ve: Ashgate Publishing Company., 1995, 120.
[6] Ibid., 120.
[7] Ibid., 116.
[8] O'Neil Jr., H.R. and Andrews, DH. *Aircrew Training and Assessment*. Mahwah, New Jersey: Lawrence Erlbaum Associates, Inc., 2000, 169.
[9] Ibid., 169.
[10] Ibid., 174.
[11] Wiener, E.L., Kanki, B.G., and Helmreich, RL., *Cockpit Resource Management.* San Diego, Ca: Academic Press, Inc., 1993, 341.
[12] Ibid., 341.
[13] Ibid., 343.
[14] Ibid., 363.

Chapter 6

A Sensible Alternative

It is conceivable that the KC-130J can eventually be flown safely and efficiently with three to four crewmembers. This will require appropriate training resources along with a long-term reduction in crew complement and potentially a reduction in overall capability. A look at the successful C-17 training program and resources provides the closest comparison to the challenges facing the KC-130 community.

The C-17 mission is broken down into two basic missions: airdrop and airland.[1] Each squadron separates their aircrews into airdrop and airland crews. This allows the airdrop-qualified crews focus their training and maintain their proficiency in the airdrop mission while the remaining crews perform the airland mission. Since the squadron only needs a certain percentage of its aircrew current in the airdrop mission, there are enough aircraft resources to conduct the training missions.

Aircraft resources combined with simulator resources provide the necessary training aids to train and maintain proficiency in the airdrop mission. For the airdrop mission, C-17 pilots are required to perform one airdrop sortie in the aircraft each quarter in order to maintain currency. Additionally, the aircraft commanders are required to fly one simulator sortie per quarter while the copilots are required to fly two simulator sorties per month.[2] These training resources and currency requirements for the airdrop appear reasonable because the C-17 program has been successful.

The Marine Corps KC-130J program does not have the same resource luxuries as the C-17 community. As of FY01, the Marine Corps will have 11 KC-130J aircraft funded with an acquisition plan of 4 aircraft per year until the 51 aging KC-130 F and R Models are replaced. The J-Model was initially purchased by congress without any logistical or training support making it impossible to establish the appropriate training resources prior to delivery of the aircraft. Since the initial buy, funds have been made available for logistics tail and aircrew trainers. However, only one aircrew simulator is projected for acquisition in FY03 and will be delivered to the East Coast KC-130 squadron.[3]. The West Coast squadron is "penciled in" for a simulator in FY07 however this remains an unfunded requirement.[4] The lack of simulator resources places a larger training burden on the aircraft.

Without a simulator, the aircraft becomes the primary emergency procedures trainer placing additional strain on the squadron because aircraft availability for METL training let alone emergency procedures training is quite limited. The squadron's normal external support mission requirements will utilize anywhere from 60 – 100 percent of the aircraft. Many of these missions are not conducive to squadron training. The remaining aircraft have to be managed carefully to get the maximum amount of training. Currently, the KC-130 squadrons are strained to provide aircraft to meet the KC-130 F&R model training requirements utilizing a crew compliment of six. With a crew complement of three, the KC-130J will require even more training missions.

Based on the assumption that the KC-130J currency requirements are at least as stringent as the C-17, the sortie rate will have to increase for KC-130J with a three-person crew in order to maintain currency in the core competencies. On the KC-130 F & R, the flight engineer and navigator provide more than just systems monitoring and navigation assistance to the flight deck. They bring a substantial level of experience to the aircrew and the synergistic effect of working as a crew allow the KC-130 community to safely conduct the missions in support of the METL with lengthy refly factors. For example, instead of the current KC-130 currency requirement of one airdrop per year, now the pilots will have to fly four airdrops per year. Additionally, with the Night Vision Lighting capability, additional sorties are required to train and maintain proficiency. There will also be additional sorties required for emergency procedures training for squadrons that do not have a simulator. With increased sortie requirements, additional aircraft resources have to be made available.

In order to gain additional aircraft resources, the external support mission requirements have to be significantly reduced or the individual aircraft sortie rate must increase. The external support mission requirements are not likely to decrease due to the MEF and Wing training and support requirements. KC-130 squadrons constantly battle higher headquarters to reduce the external support mission requirement so the aircraft can be utilized for squadron training. There is potential for the individual aircraft sortie rate to increase with the potential reduction in maintenance requirements. However, it will probably be difficult to sustain an increased flight operations tempo. With 12 aircraft assigned, the squadron will have to fly more than 6 aircraft per day, which is the current average. With scheduled and unscheduled maintenance, available to fly is reduced leading the squadron to fly close to 100 percent of available assets on a regular basis. Additionally, increased funding is required to support the additional flight; another significant challenge in these fiscally constrained times. Along with increasing sorties for training, the aircraft commanders need to increase their experience level.

Sortie rate will have to increase in order to enhance the aircraft commander's experience level. Currently, the young aircraft commanders have the navigator's and flight engineer's expertise and experience to utilize during emergencies. While the navigator provides navigation assistance, the greatest loss will probably be the flight engineer who brings substantial systems knowledge and experience to the flight deck enabling the aircraft commander to concentrate on managing the crew during an emergency while the flight engineer diagnosed systems malfunctions/failures. The navigator and flight engineer also bring two extra sets of eyes to the flight deck significantly enhancing safety, especially in the terminal environment when traffic is the heaviest. The loss of one or both of these crewmembers in the cockpit will substantially increase the workload/stress on the aircraft commander. With pilot experience relatively low, the loss of key crewmembers on the flight deck, and the myriad of missions that the pilots are required to be proficient in, the proposed KC-130J training resources will not be enough to maintain proficient and safe aircrew. When introducing the KC-130J, these deficiencies need to be overcome.

The Marine Corps should set a long-term goal to reduce the crew requirements to three or four crewmembers when effective training resources become available. In the short term, strive to keep the safety record that the KC-130 community has worked hard to attain. The minimum crew for the KC-130J should be relatively the same as the minimum crew for the KC-130 F/R/T (pilot, copilot, flight engineer, flight mechanic) except replace the flight mechanic with the loadmaster. This eliminates one crew position (manpower savings). Since the flight engineer is central to the CRM process that KC-130 pilots are used to, he/she can continue to bring that aviation experience to the flight deck. The systems knowledge that they are so well versed in and the extra set of eyes on the flight deck significantly enhances the safety of flight. At the same time, the flight engineer provides the capability to operate independently around the world with minimum maintenance support from home base. Utilizing this minimum crew concept will go a long way towards maintaining the incredible safety record of the KC-130 community however it does not take into account all the tactical missions as well as the long-term goal of reducing the crew.

In order to assist the aircraft commander in the tactical missions, the navigator should be added to those particular flights. Utilizing the navigator on tactical missions provides that buffer of safety that he/she currently provides with the lengthy refly factors. Utilizing the minimum crew and augmenting with the navigator will provide a common CRM framework that the pilots are used to, maintain the lengthy refly factors making it possible to maintain aircrew proficiency with the current sortie rate, and eliminate one crew position altogether: the flight mechanic.

The long-term goal of reducing the crew even further should be assessed, as more training resources become available. Utilizing the concept of five crewmembers would be the best step forward towards maintaining the safety record and the efficient operations of the KC-130 community while gaining manpower savings. Once the simulator is online, training regimens can be evaluated to determine if the navigator position can be eliminated. However, even with simulator training, more training flights are required in the aircraft to maintain proficiency like is done in the C-17 community. To attain the same sortie training level as the C-17, the external support mission requirements will have to be reduced or the sortie rate increased. Only then should the elimination of the navigator on tactical missions be considered. This leaves the flight engineer as the last member to be considered in a long-term plan.

Not only is the flight engineer key in the CRM and safety aspect of aircraft operations, he/she has been crucial in the maintenance of the aircraft when independently deployed. Since the flight engineer has been trained to repair just about everything on the aircraft, the squadron rarely has to send maintenance Marines to the deployed site to repair the aircraft. This reduces the burden on the squadron maintenance deck because they do not have the personnel to regularly send on the road in support of independent aircraft operations. The "political" problem is establishing an "aircrew" position for maintenance purposes.

The KC-130 community would be well served by keeping the flight engineer capability as an "aircrew" position on the J-model. It has been argued that the J-Model no longer needs a flight engineer and that we don't establish an "aircrew" position just for maintenance. However, along with the contributions to the safety of flight issues previously discussed, he/she has been responsible for repairing aircraft when operating independently keeping our mission success rate quite high. There is no doubt without this crewmember's capability, our mission success rate will drop; nobody will be around to repair the aircraft. Although the maintenance deck could send a Marine on these flights, this individual will have to be trained to the maintenance capability of a flight engineer. Additionally, there are no manpower savings because the maintenance deck manning level will have to be increased to provide these highly trained maintenance personnel for the flights. Maintaining this maintenance capability in conjunction with the flight engineer's experience as an aircrew member on the flight deck on the KC-130J will go a long way to maintaining KC-130 *efficiency* as well as safe operations while deployed.

In the interest of safety, the Marine Corps should take this transition slowly. Utilize the current crew complement minus the flight mechanic. Only when simulator resources and increased sortie rates have been realized and are sustainable across all of the KC-130 squadrons should consideration be given to eliminating the navigator position. Eventually eliminating the flight engineer capability will substantially impact safety of flight and the efficiency/reliability of KC-130J operations. No amount of glass technology can replace the flight engineer's experience and situational awareness in the cockpit. Careful analysis of the safety risks and mission success rate –vs.- manpower savings should be conducted prior to determining whether or not to eliminate the flight engineer.

Notes

[1] USAF Fact Sheet. C-17 Globemaster III. Online, Internet, Available from http://www.af.mil/news/factsheets/C_17_Globemaster_III.html.

[2] Air Force Instruction 11-2C-17V1, *C-17 Aircrew Training*, 10 February 2000.

[3] United States Marine Corps, *Aviation Simulator Master Plan*, October2000.

[4] Ibid.

Chapter 7

Conclusion

The KC-130's primary mission is aerial refueling. However, a secondary mission is the transportation of cargo and personnel. With the capability to transport up to 90 service members and/or civilian dependents, we have to ask ourselves: is it smart to risk the safe operation of the KC-130J by reducing the crew complement in the search of manpower savings? Risk is part of military aircrew life but it does not have to be increased to save a few dollars.

The overwhelming majority of glass technology users in transport aircraft are highly experienced airline pilots who fly fairly benign missions. The pilots in the KC-130 community do not even come close to that level of experience yet they have to fly even more complicated missions. The KC-130 community has proven through their incredible safety record that they can accomplish their missions safely and efficiently and we need to keep in mind that it has been a team effort of all members of the aircrew that have contributed to that safety record.

Without the resources of additional training sorties, the KC-130J aircrew will not be able to fly enough sorties in an attempt to maintain three-person crew proficiency along the same lines as the C-17. Initial testing with fairly experience crewmembers may prove satisfactory for a three-person concept. However, once the squadrons begin sustained operations with the KC-130J, the risk will substantially increase with younger aircrew performing the missions. There is a sensible alternative.

With a *long*-term goal of reducing the crew complement the Marine Corps can implement a crew transition strategy that maintains an environment closely related to the current safe operations while minimizing the impact to operations efficiency. Since the J-model pilots can perform many of the flight engineer and navigator in-flight duties, the roles of these two positions will change somewhat. The flight engineer can still bring systems expertise, experience and most of all CRM contributions to the cockpit. Since this individual will no longer be *physically* controlling many of the control panels, this position can be designated as a crew chief.

The navigator is not required for benign missions because the pilots have access to all navigation systems. However, for the high demand tactical environment, this individual can work the navigation systems at the augmented crew station reducing the workload on the pilots. With this individual only augmenting on tactical flights, this position can be designated the tactical systems operator (TSO). Maintaining the flight engineer and navigator capability on the J-model at the start of the transition process is smart because it provides the same level of safety enjoyed by the KC-130 community

The Marine Corps should establish a minimum crew of four: pilot, copilot, crew chief and loadmaster. This provides the same CRM capabilities that the current crews utilize minimizing the shock to this radically new technology. For tactical missions, the TSO should be added to provide the same comfort level of safety utilized in the current KC-130 F/R environment reducing the workload on the pilots. With this concept, the flight mechanic is eliminated (manpower savings), the risk to safety is minimized, and the crew still retains the capability to repair the aircraft when operating independently.

When simulator resources *and* additional training sorties become available, consideration should be given to eliminating the TSO requirement. This can be reasonably accomplished when the aircrews are able to fly enough aircraft *training* sorties to maintain proficiency.

It is quite possible to safely employ the KC-130J with three crewmembers. It was designed and FAA certified for three crewmembers. Other glass technology aircraft like the C-17, military fighter aircraft, and commercial airlines are successfully employed with reduced crew. The difference between the KC-130J and these other aircraft is training and experience. The C-17, fighter aircraft and commercial airlines have the training resources to keep their pilots well trained and *proficient*. The KC-130J program does not. Until the appropriate resources become available to the KC-130J community, the recommended minimum crew of four with the TSO augmenting on tactical missions should be maintained.

It appears this paper is arguing to keep the same "good ol' boys" in the J model in the name of safety. Can the KC-130 community be too safe? There is no reason to introduce additional risk into this aircraft for personnel savings at the expense of safety. It is said that the NATOPS flight manual is written in blood. Lets not spill any blood to find out that a three-person crew complement is not enough for the KC-130 community's relatively inexperienced pilots.

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